Kit 67. DC SPEED CONTROLLER

There are three ways to vary the speed of DC motors:

- use a gear-box.
- use a series resistor. Measure the current drawn by the motor and then calculate the value of a series resistor needed to drop the voltage applied to the motor. Less voltage means the motor will slow down. The problem with this method is that the current drawn by the motor increases as the load on the motor increases. More current means a larger voltage drop across the series resistor and therefore less voltage to the motor. The motor now tries to draw even more current, resulting in the motor stalling.
- by applying the supply voltage to the motor for a variable amount of time, eliminating the series dropping effect. This is the method used in this kit.

How It Works

The circuit uses two timer/oscillators connected as a Pulse Width Modulator. The chip used is an nmos dual timer/oscillator, NE556. This IC has two 555 timers in one 14-pin IC package.

One 555 (IC1:B) is configured as an astable oscillator. The output frequency of the trigger pulses is given by:

$f = 1.44 / ((R_3 + 2R_4)C_2)$, or about 410Hz.

The time period for the high output is given by

$T_{HIGH} = 0.69(R_3 + R_4)C_2$ seconds.

And, the low output by $T_{LOW} = 0.69R_4C_2$ seconds.

The second 555 (IC1:A) is configured for Pulse Width Modulation. It is set up in monostable mode. It is triggered with the continuous pulse train from the first 555. However, by also applying a DC voltage to pin 3 the comparator reference levels will be changed from their nominal levels of one-third & two-thirds of the supply voltage. This has the effect of modulating the pulse width as the control voltage varies.

The control voltage is supplied via transistor Q1, which is configured as an emitter-follower. This means that the emitter output voltage follows the base input voltage (less 0.6 volt base-emitter drop). This configuration gives us a low output impedance voltage source with which to drive the control input of the timer. This makes the control voltage less susceptible to the loading effect of the timer control input.

The output from the timer is a continuous stream of pulses whose width is controlled by the voltage level applied to the control voltage input. This modulated output drives a power darlington transistor, Q2, which is used to switch the voltage to the DC motor.

The maximum ON time of the output pulse, and therefore maximum motor speed, can be set by changing the value of resistor R1. Increasing the value lowers the maximum motor speed. The end stop resistor R1 may be replaced by a link if desired.

The motor is always connected to the 3 pole terminal block, pins + and -. If the motor is driven with the same power supply as the controller then insert link LK1. If separate power supplies are used to drive the controller and the motor, then remove link LK1 and connect the positive motor power supply lead to the EXT pin. Make sure that the ground lines from each supply are tied together.

Construction

First check that you have all the components. Check each component against the Listing given on the next page. Make sure to get the orientation of the diode and electrolytic capacitor correct. The bar on the diode is the cathode and corresponds with the bar on the overlay printed on the circuit board.

It is generally easiest to add and solder the lowest height components first to the PCB. Then add the taller components. Note there are two links to add to the board. If the motor and the controller use the same power supply (5V - 15V) then add the third link to the board. When you add the TIP122 bend the legs 90° using needle nosed pliers. Do not just push it over with your fingers as this may break the IC case. Before you solder the TIP122 put the heatsink into place underneath it with the screw & nut fastened. Use some heatsink paste if you have it.

10K potentiometer. This is mounted from the back through the hole on the right of the board. Screw it down with the nut. Use some of the wires from the resistors to attach the three pins from the pot to the 3 pads marked with the circles on the overlay. We have not included a knob with the kit so that you can attach the one you like best, or use a spare one if you have it.

Operating Specifications

V_{CC} : 5V - 16V. This is the operating range of the 556 IC.

DC motor: Up to 100V at a maximum of 5A. This comes from the operating specifications of the TIP122 switching transistor.

If the motor runs in the same range as V_{CC} then both the Speed Controller & the motor can be run from the same power supply. Connect the link on the PCB. If the motor runs at a higher voltage then do not connect the link. Connect the motor external supply to the terminal block and tie the ground lines together.

K2657 SLOW ON / SLOW OFF DIMMER

INTRODUCTION

One could call this dimmer a "soft switch". The lamp does not go on or off instantly, but slowly. Dimming times are adjustable within a wide range. The number of possible applications is increased by the two working modes :

a) dimming slowly. The lamp goes on or off slowly, depending on the position of a simple switch or relay contact. Both speeds are adjustable independently (2 seconds up to one hour). For use in aviaries, slide projectors, aquariums, bedrooms, etc.
b) timer/dimmer. Just push the button and the lamp is on at full brightness immediately. It stays on for a while, and then fades away slowly. Both on-time, and dimming speed are adjustable independently (1 sec. Up to 30 min.). Very well suited for garages, stairs, passages, as a slumber switch etc.

TECHNICAL DATA

Two working modes:

a) dimming slowly. Dimming on and off times adjustable independently (2 seconds up to 1 hour)
b) timer/dimmer. On-time and dimming speed adjustable independently (1 sec. Up to 30 min.)

Mains voltage : 110-125 or 220-240V, 50 or 60 Hz
Max. Load: 2A (400W at 220V or 200W at 110V
Power supply included

SLOW ON / OFF DIMMER ASSEMBLY AND TOOLS

Check that you have all the parts..

RECOMMENDED TOOLS

Miniature 25W soldering iron
Multicore solder
Soldering iron stand and sponge

ASSEMBLY

Fitting J1, J2, R23 and R30 differs depending on the chosen version :

1A. If you want to use your K2657 as a slow on / slow off dimmer :

Jumper wire

Inventory	Sequence of assembly	Part number / description
○	○	Fit the jumpers J1

These resistors are not polarized, so they can be inserted either way. Only the four primary color bands are mentioned. There may be a fifth band which can be ignored.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	R23	100KΩ metal film (brown-black-black-orange-brown or red)
○	○	R30	51KΩ metal film (green-brown-black-red-brown or red)

1B. If you want to use your K2657 as a slow on / slow off dimmer :

Jumper wire

Inventory	Sequence of assembly	Part number / description
○	○	Fit jumper J2.
○	○	Fit a jumper for R30

Diodes

Inventory	Sequence of assembly	Reference	Part number / description
○	○	R23	Fit R23, a 1N914 or 1N4148 type small signal diode. Pay attention to the polarity! The 1N4148 type may have a color code (large yellow band, brown, yellow, gray). In this case the large yellow band marks the cathode. When the diode is identified by a number, then the black band marks the cathode. Pass the cathode through the hole marked "C" (at the T1 side).

2. JUMPER WIRES

Inventory	Sequence of assembly	Part number / description
○	○	Fit the two jumpers J, identified by a line on the PCB.

3. DIODES

Align the banded end with the band drawn on the PCB board.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	D1 to D3	1N914 or 1N4148 type small signal diodes. IMPORTANT : In the case of a 24V supply, you must fit for D1 two diodes connected in series (see figure 1). Pay attention to the polarity! The 1N4148 type may have a color code (large yellow band, brown, yellow, gray). In this case the large yellow band must correspond with the strip on the board. If the diode is identified by a number, then the black band has to correspond with the band on the board.
○	○	D4	Fit D4, a diode from the 1N4000 series. Pay attention to the polarity!
○	○	ZD1	Zener diode 5.6V (marked as 5V6) for 110 through 240V mains voltage, **or** 4.7V(marked as 4V7) with 24V supply. Pay attention to the polarity!

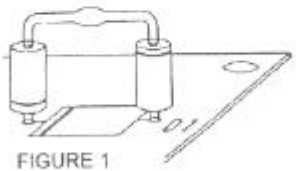


FIGURE 1

4. METAL FILM RESISTORS

Resistors are not polarized, so they can be inserted in either direction. Only the three primary color bands are mentioned. There may be a fourth band which can be ignored.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	R15 to R22	100KΩ (brown-black-black-orange-brown or red)
○	○	R24 to R29	51KΩ (green-brown-black-red-brown or red)

5. RESISTORS

Resistors are not polarized, so they can be inserted in either direction. Only the three primary color bands are mentioned. There may be a fourth band which can be ignored.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	R1	→ with 220-240V mains voltage fit a 220KΩ (red-red-yellow-gold) → with 110V fit a 100KΩ (brown-black-yellow-gold) → with 24V fit a 15KΩ (brown-green-orange-gold)
○	○	R2	→ with 220-240V mains voltage fit a 470KΩ (yellow-violet-yellow-gold) → with 110V fit a 220KΩ (red-red-yellow-gold) → with 24V fit a 39KΩ (orange-white-orange-gold)
○	○	R3	→ with 110-240V mains voltage fit a 470KΩ (yellow-violet-yellow-gold) → with 24V you must fit a jumper instead of R3.

3. DIODES

Align the banded end with the band drawn on the PCB board.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	D1 to D3	1N914 or 1N4148 type small signal diodes. IMPORTANT : In the case of a 24V supply, you must fit for D1 two diodes connected in series (see figure 1). Pay attention to the polarity! The 1N4148 type may have a color code (large yellow band, brown, yellow, gray). In this case the large yellow band must correspond with the strip on the board. If the diode is identified by a number, then the black band has to correspond with the band on the board.
○	○	D4	Fit D4, a diode from the 1N4000 series. Pay attention to the polarity!
○	○	ZD1	Zener diode 5.6V (marked as 5V6) for 110 through 240V mains voltage, **or** 4.7V(marked as 4V7) with 24V supply. Pay attention to the polarity!

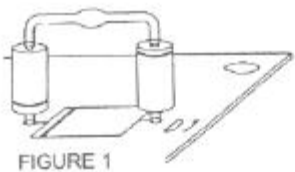


FIGURE 1

4. METAL FILM RESISTORS

Resistors are not polarized, so they can be inserted in either direction. Only the three primary color bands are mentioned. There may be a fourth band which can be ignored.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	R15 to R22	100KΩ (brown-black-black-orange-brown or red)
○	○	R24 to R29	51KΩ (green-brown-black-red-brown or red)

5. RESISTORS

Resistors are not polarized, so they can be inserted in either direction. Only the three primary color bands are mentioned. There may be a fourth band which can be ignored.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	R1	→ with 220-240V mains voltage fit a 220KΩ (red-red-yellow-gold) → with 110V fit a 100KΩ (brown-black-yellow-gold) → with 24V fit a 15KΩ (brown-green-orange-gold)
○	○	R2	→ with 220-240V mains voltage fit a 470KΩ (yellow-violet-yellow-gold) → with 110V fit a 220KΩ (red-red-yellow-gold) → with 24V fit a 39KΩ (orange-white-orange-gold)
○	○	R3	→ with 110-240V mains voltage fit a 470KΩ (yellow-violet-yellow-gold) → with 24V you must fit a jumper instead of R3.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	R4	4K7Ω (yellow-violet-red-gold)
○	○	R5 and R6	22KΩ (red-red-orange-gold)
○	○	R7	68KΩ (blue-gray-orange-gold)
○	○	R8 to R14	10KΩ (brown-black-orange-gold)

6. SOCKET

Inventory	Sequence of assembly	Part number / description
○	○	Fit an 8-pin socket for IC1
○	○	Fit a 14-pin socket for IC2
○	○	Fit a 16-pin sockets for IC3 and IC4

7. TRIMMERS

Inventory	Sequence of assembly	Reference	Part number / description
○	○	RV1	1MΩ trimmer
○	○	RV2 and RV3	470KΩ or 500KΩ trimmers

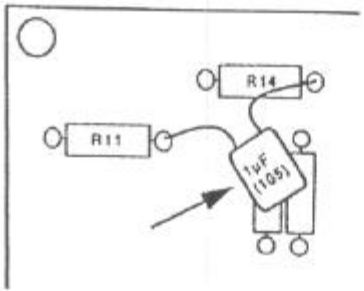
8. CAPACITORS

These capacitors are not polarized, so they can be inserted either way.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	C1	4,7 nF ceramic (sometimes marked 472, sometimes 4n7)
○	○	C2, C3 and C4	100 nF Sibatit

IMPORTANT

Inventory	Sequence of assembly	Part number / description
○	○	Mount a 1µF capacitor see figure (Sometimes marked as 105)



9. TRANSISTORS

The transistor has a flat side and rounded side. The flat side faces the same direction as the flat side drawn on the PCB board.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	T1 and T2	BC557, BC558 or BC559 type transistors

10. SCREW CONNECTORS

Inventory	Sequence of assembly	Reference	Part number / description
○	○	J3 and J4	Screw connectors. The position of screw connector J4 is application dependent : in the case of a slow dimmer the connector has to be mounted on the side marked "J4" (SW and N), in the case of a timer/dimmer on the other side (N and PB)

11. THE ELECTROLYTIC CAPACITORS

Note carefully the positive leads before you fit the capacitor into the PCB board.

Inventory	Sequence of assembly	Reference	Part number / description
○	○	C5	10 µF
○	○	C6	100 µF
○	○	C7, C8 and C9	1 µF
○	○	C10	4,7 µF

12. POWER RESISTORS

Inventory	Sequence of assembly	Reference	Part number / description
○	○	R31	Power resistor : With 220-240V mains voltage use 15KΩ/W With 110V use 8K2Ω / 5W With 24V use 470Ω / 1W For proper cooling, do not mount these resistors tight to the PCB but with clearance between the board and the body of the resistor.

13. TRIAC

Inventory	Sequence of assembly	Reference	Part number / description
○	○	TR1	TIC226 type triac or equivalent

Fit the triac with its metal back towards the screw connector. If you want the dimmer to be able to supply higher currents (up to max. 6A) e.g. for a 24V/150W lamp in a slide projector, then you must mount the triac to a heat sink, and connect it to the PCB by means of wires (don't make any mistake about the connection order, and insulate the connections sufficiently!). As a heat sink you may use a (vertically fixed) 1/8 inch (3mm) thick aluminum plate with a surface of 14in² 100cm², or a commercially available heat sink with a thermal resistance lower than 5°C/W.
Attention : the heat sink is connected to the mains voltage via the triac, so it has to be
insulated from the chassis!

13. INTEGRATED CIRCUIT (IC)

Inventory	Sequence of assembly	Reference	Part number / description
○	○	IC1	TEA1007, with its notch towards the capacitors
○	○	IC2	4093, with its notch towards D3 and R13
○	○	IC3	4516, with its notch towards R11
○	○	IC4	4516, with its notch towards R26

ATTENTION !!!

THE CIRCUIT USES HIGH VOLTAGE ELECTRICITY, SO ALL COMPONENTS CARRY DANGEROUS VOLTAGES. BE VERY CAREFUL WHEN TESTING AND ADJUSTING! AFTER COMPLETION OF THE CIRCUIT YOU SHOULD MOUNT THE DIMMER INTO A PLASTIC HOUSING. A METAL HOUSING, WHEN USED, MUST BE EARTHED !
USE ONLY SWITCHES AND/OR PUSH BUTTONS SUITED FOR HIGH VOLTAGE !

TEST AND ADJUSTMENT

Turn all trimmers to their center position.
Connect a lamp to the points P and N (LOAD)

a) slow on/slow off dimmer (fig. 2)

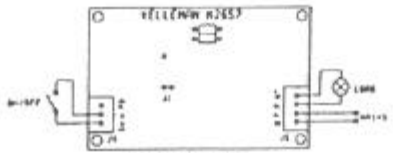


FIGURE 2

Connect an ordinary single pole switch to the points N and SW. Put the switch in the OFF position. Connect the mains voltage to the points N and P (MAINS). Mind the high voltage on the circuit !
The lamp may dim slightly. After switching on, wait a couple of minutes, to be sure the lamp doesn't fade out any further. Now adjust with RV1 until the lamp is just off completely.
Put the switch in the ON position. The lamp should go on slowly. After about twenty seconds (adjustable with RV3) the lamp is on at full capacity. As soon as the switch is off, the lamp starts fading slowly. After about twenty seconds (adjustable with RV2) it has to be off completely.

b) timer/dimmer (fig. 3)

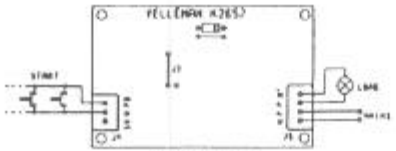


FIGURE 3

Connect a push button to the points N and PB.
Connect the mains voltage to the points N and P (MAINS)
Mind the high voltage on the circuit !
The lamp may dim slightly. After switching on, wait a couple of minutes, to be sure the lamp doesn't fade away any further. Now adjust with RV1 until the lamp is just off completely.
Push the button and the lamp begins to light at full capacity immediately. After about ten seconds (adjustable with RV3) the lamp fades away slowly. After another ten seconds (adjustable with RV2) it is off completely.

OPTIONS AND USING EXAMPLES

The times, adjustable with RV2 and RV3 can be made longer by a factor of ten or hundred, if necessary. To do so, for the OFF-time (RV2), you have to replace C7 by a 10 or 100uF capacitor. (Pay attention to the polarity!). For the ON-time you have to replace C8 (see table). Capacitors C7 and C8 may have different values.

Depending of the chosen variation of the dimmer, either a switch is connected to SW or a push button to PB. However, you may also use them both together: with the slow dimmer, pushing the button will cause the lamp to dim out slowly. On the other hand, using a switch with the timer/dimmer results in the combination of a slowly-on dimmer together with a slumber switch (fig. 4).

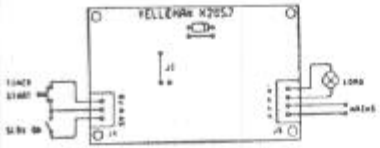


FIGURE 4

Closing the switch causes the lamp to go on slowly (adjustable with RV2). After the switch is off, the lamp stays on at full capacity for a while (adjustable with RV3), and then fades away slowly. This can be very useful, e.g. for the lighting of the nursery: in this way a child can fall asleep quietly, and he isn't startled when the light goes on again. In this case the dim-on and-out speeds cannot be adjusted independently.

There are two ways to dim low voltage halogen lamps :

a) before the transformer (fig. 5). This way you can control, without changes, as much power as when using ordinary lamps.

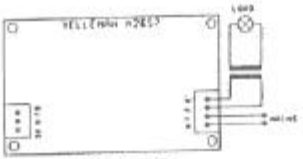


FIGURE 5

b) after the transformer. This is only possible with 24V secondary voltage.
In most slide projectors, the transformer is also used to feed the electromagnets and motors, so you have to put the dimmer after the transformer. In this case you need a higher current for the same power. The supplied triac can control up to 6A (thus 150W at 24V), on the condition that it is cooled sufficiently (see above).

A nice example of this is a slide-show with two projectors and two K2657 (see fig. 6).

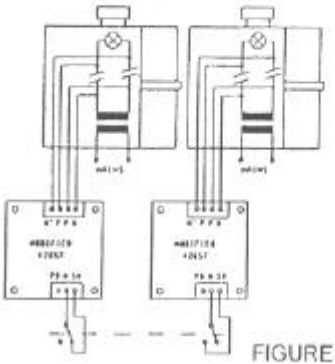
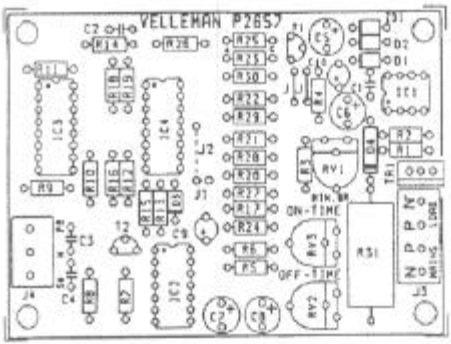


FIGURE 6

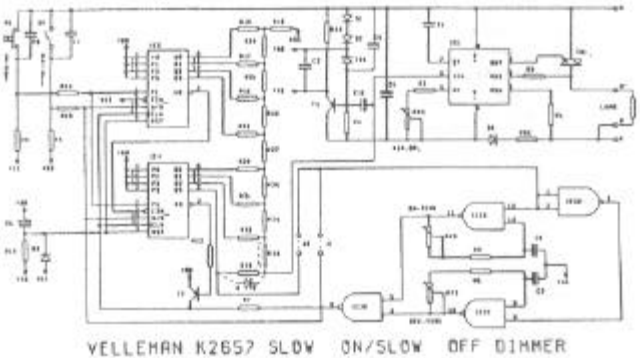
Except for safety (insulation), not many demands are made upon push buttons and switches. You may put several push buttons in parallel to control the dimmer from different places. Although the inputs are filtered by capacitors, you still have to take care that the cables between the switches and/or push-buttons and the inputs pick up as little noise as possible: always twist the wires ("twisted pair", like telephone cable). Use screened cable (screen to N) should the cables become too long.

SLOW ON / SLOW OFF DIMMER			
C2	OFF-TIME	C3	ON-TIME
1nF	2sec ...90sec	1nF	2sec ...90sec
10nF	30sec ... 5min	10nF	30sec ... 5min
100nF	5min ... 1h	100nF	5min ... 1h

TIMER / DIMMER			
C2	OFF-TIME	C3	ON-TIME
1nF	0sec... 15sec	1nF	0sec... 15sec
10nF	15sec...3.5min	10nF	15sec...3.5min
100nF	3.5min... 30min	100nF	3.5min... 30min



Slow on / Slow off dimmer
PCB layout and
Component Layout



Slow on / Slow off dimmer
Schematics